with aspect ratio 16:9, and may be trimmed of side panels to use as a 960×720 image frame with aspect ratio of 4:3 in conventional television formats such as NTSC or PAL. After a 2:1 expansion/re-sizing, the HDTV format **202** is available, with frame size 2560×1440 and the same 16:9 aspect ratio. A further 2:1 expansion/re-sizing to the film format **204**, with frame size 5120×2880 and the same 16:9 aspect ratio, allows for recording of film via currently available technology.

FIG. **1D** shows another alternative family of aspect ratios and image frame sizes in pixels. The internal production storage format **206** has frame size 1280×960 with aspect ratio 4:3 as employed in conventional television formats such as NTSC or PAL, and may be trimmed of top and bottom panels to use as a 1280×720 image frame with aspect ratio of 16:9. After a 2:1 expansion/re-sizing, the intermediate format **208** is available, sizing to the alternative film format **209**, with frame size 5120×3840 and the same 4:3 aspect ratio, allows for recording of film via currently available technology.

Alternative implementations may employ different frame size (in pixels), aspect ratios, or frame rates, and these variations should be considered to be within the scope of the invention.

FIG. **7** shows an implementation involving one possible choice for image sizes, aspect ratios, and frame rates to provide a universal television production system. As shown, signals are provided from any of several sources, including conventional broadcast signals **210**, satellite receivers **212**, and interfaces to a high bandwidth data network **214**. These signals would be provided to the digital tuner **218** and an appropriate adapter unit **220** for the data network or "information superhighway" before being supplied to the decompression processor **222**. The processor **222** provides any necessary data de-compression and signal conditioning for the various signal sources, and preferably is implemented as a plug-in circuit board for a general-purpose computer, though the digital tuner **218** and the adapter **220** optionally may be included as part of the existing hardware.

The output of processor **222** is provided to the internal data bus **226**. The system microprocessor **228** controls the data bus, and is provided with 16 to 64 MB of RAM **230** ad up to 64 Mb of ROM **232**. This microprocessor could be implemented using one of the units previously described, such as the PowerPC 604 or PowerPC 620. A hard disk drive controller **234** provides access to various storage means, including, for example, an internal hard disk drive unit **236**, a removable hard disk drive unit **238**, or a tape drive **240**; these storage units also enable the PC to function as a video recorder, as described above. A graphic processor **242**, comprising dedicated hardware which optionally be implemented as a separate plug-in circuit board, performs the image manipulations required to convert between the various frame sizes (in pixels), aspect ratios, and frame rates. This graphics processor uses 16 to 32 MB of DRAM, and 2 to 8 MB of VRAM, depending on the type of display output desired. For frame size of 1280×720 with an aspect ratio 16:9, the lower range of DRAM and VRAM will be sufficient, but for a frame size of 2048×1152, the higher range of DRAM and VRAM is required. In general, the 1280×720 size is sufficient for conventional "multi-sync" computer display screens up to 20 inches, and the 2048×1152 size is appropriate for conventional "multi-sync" computer display screens up to 35 inches. Analog video outputs **244** are available for these various display units. Using this system, various formats may be displayed, including (for 25 fps, shown by speeding up 24 fps signals) 768×576 PAL/SECAM, 1024×576 wide-screen, and 2048×1152 HDTV, and (for 30 fps, shown by utilizing the well-known "3:2 pull-down" technique, and for 29.97 fps, shown by a slight slow-down in 30 fps signals) 640×480 NTSC and 854×480 wide-screen, and 1280×720 USA and 1920×1080 NHK (Japan) HDTV. While most NTSC monitors will synchronize to a 30 fps signal, possibly requiring that the color subcarrier frequency be adjusted, many PAL and SECAM monitors will not accept a 24 fps signal. In this case, more sophisticated frame-rate conversion techniques may be required for viewing live broadcasts, since the 24 fps input signal rate cannot keep pace with the 25 fps display rate. However, in practice it is anticipated that future television sets will incorporate "multi-sync" designs that eliminate this potential problem.

Having described the invention, we claim:

1. A multi-format audio/video production system adapted for use with a display device comprising:

means to receive an input signal representative of an audio/video program in one of a plurality of display formats;

a graphics processor connected to receive the audio/video program and convert the display format of the program into an intermediate production format, the graphics processor including:

a standard/widescreen interface unit operative to convert the video program in the production format into an output signal representative of a standard/widescreen formatted program, and

a high-definition television (HDTV) interface unit operative to convert the video program in the production format into an output signal representative of an HDTV-formatted program;

high-capacity video storage means;

an operator interface; and

a controller in operative communication with the means to receive the input signal, the graphics processor, the high-capacity video storage means and the operator interface, whereby commands entered by an operator through the interface cause the following functions to be performed:

(a) the conversions of an audio/video program into the production format,

(b) storage of a program in the production format in the high-capacity video storage means,

(c) the conversion of a program in the production format into a standard/widescreen program, either directly from the means to receive the input signal or from the high-capacity video storage means, and

(d) the conversion of a program in the production format into an HDTV program, either directly from the means to receive an input signal or from the high-capacity video storage means.

2. The multi-format audio/video production system of claim **1**, the graphics processor further including a film output video interface, the controller further being operative, in response to a command entered by an operator, to convert the video program in the input format into an output signal for photographic production, either directly from the means to receive the input signal or from the high-capacity video storage means.

3. The multi-format audio/video production system of claim **1**, including input and output signals compatible with any of the following standard formats: RGB, YIQ, YUV, and Y/R-Y/B-Y.

4. The multi-format audio/video production system of claim **1**, including input and output signals compatible with

with aspect ratio 16:9, and may be trimmed of side panels to use as a 960×720 image frame with aspect ratio of 4:3 in conventional television formats such as NTSC or PAL. After a 2:1 expansion/re-sizing, the HDTV format **202** is available, with frame size 2560×1440 and the same 16:9 aspect ratio. A further 2:1 expansion/re-sizing to the film format **204**, with frame size 5120×2880 and the same 16:9 aspect ratio, allows for recording of film via currently available technology.

FIG. 1D shows another alternative family of aspect ratios and image frame sizes in pixels. The internal production storage format **206** has frame size 1280×960 with aspect ratio 4:3 as employed in conventional television formats such as NTSC or PAL, and may be trimmed of top and bottom panels to use as a 1280×720 image frame with aspect ratio of 16:9. After a 2:1 expansion/re-sizing, the intermediate format **208** is available, sizing to the alternative film format **209**, with frame size 5120×3840 and the same 4:3 aspect ratio, allows for recording of film via currently available technology.

Alternative implementations may employ different frame size (in pixels), aspect ratios, or frame rates, and these variations should be considered to be within the scope of the invention.

FIG. **7** shows an implementation involving one possible choice for image sizes, aspect ratios, and frame rates to provide a universal television production system. As shown, signals are provided from any of several sources, including conventional broadcast signals **210**, satellite receivers **212**, and interfaces to a high bandwidth data network **214**. These signals would be provided to the digital tuner **218** and an appropriate adapter unit **220** for the data network or "information superhighway" before being supplied to the decompression processor **222**. The processor **222** provides any necessary data de-compression and signal conditioning for the various signal sources, and preferably is implemented as a plug-in circuit board for a general-purpose computer, though the digital tuner **218** and the adapter **220** optionally may be included as part of the existing hardware.

The output of processor **222** is provided to the internal data bus **226**. The system microprocessor **228** controls the data bus, and is provided with 16 to 64 MB of RAM **230** ad up to 64 Mb of ROM **232**. This microprocessor could be implemented using one of the units previously described, such as the PowerPC 604 or PowerPC 620. A hard disk drive controller **234** provides access to various storage means, including, for example, an internal hard disk drive unit **236**, a removable hard disk drive unit **238**, or a tape drive **240**; these storage units also enable the PC to function as a video recorder, as described above. A graphic processor **242**, comprising dedicated hardware which optionally be implemented as a separate plug-in circuit board, performs the image manipulations required to convert between the various frame sizes (in pixels), aspect ratios, and frame rates. This graphics processor uses 16 to 32 MB of DRAM, and 2 to 8 MB of VRAM, depending on the type of display output desired. For frame size of 1280×720 with an aspect ratio 16:9, the lower range of DRAM and VRAM will be sufficient, but for a frame size of 2048×1152, the higher range of DRAM and VRAM is required. In general, the 1280×720 size is sufficient for conventional "multi-sync" computer display screens up to 20 inches, and the 2048×1152 size is appropriate for conventional "multi-sync" computer display screens up to 35 inches. Analog video outputs **244** are available for these various display units. Using this system, various formats may be displayed, including (for 25 fps, shown by speeding up 24 fps signals) 768×576 PAL/SECAM, 1024×576 wide-screen, and 2048×1152 HDTV, and (for 30 fps, shown by utilizing the well-known "3:2 pull-down" technique, and for 29.97 fps, shown by a slight slow-down in 30 fps signals) 640×480 NTSC and 854×480 wide-screen, and 1280×720 USA and 1920×1080 NHK (Japan) HDTV. While most NTSC monitors will synchronize to a 30 fps signal, possibly requiring that the color subcarrier frequency be adjusted, many PAL and SECAM monitors will not accept a 24 fps signal. In this case, more sophisticated frame-rate conversion techniques may be required for viewing live broadcasts, since the 24 fps input signal rate cannot keep pace with the 25 fps display rate. However, in practice it is anticipated that future television sets will incorporate "multi-sync" designs that eliminate this potential problem.

Having described the invention, we claim:

1. A multi-format audio/video production system adapted for use with a display device comprising:

means to receive an input signal representative of an audio/video program in one of a plurality of display formats;

a graphics processor connected to receive the audio/video program and convert the display format of the program into an intermediate production format, the graphics processor including:

a standard/widescreen interface unit operative to convert the video program in the production format into an output signal representative of a standard/widescreen formatted program, and

a high-definition television (HDTV) interface unit operative to convert the video program in the production format into an output signal representative of an HDTV-formatted program;

high-capacity video storage means;

an operator interface; and

a controller in operative communication with the means to receive the input signal, the graphics processor, the high-capacity video storage means and the operator interface, whereby commands entered by an operator through the interface cause the following functions to be performed:

(a) the conversions of an audio/video program into the production format,

(b) storage of a program in the production format in the high-capacity video storage means,

(c) the conversion of a program in the production format into a standard/widescreen program, either directly from the means to receive the input signal or from the high-capacity video storage means, and

(d) the conversion of a program in the production format into an HDTV program, either directly from the means to receive an input signal or from the high-capacity video storage means.

2. The multi-format audio/video production system of claim **1**, the graphics processor further including a film output video interface, the controller further being operative, in response to a command entered by an operator, to convert the video program in the input format into an output signal for photographic production, either directly from the means to receive the input signal or from the high-capacity video storage means.

3. The multi-format audio/video production system of claim **1**, including input and output signals compatible with any of the following standard formats: RGB, YIQ, YUV, and Y/R-Y/B-Y.

4. The multi-format audio/video production system of claim **1**, including input and output signals compatible with

a video standard utilizing separate luminance and chrominance component video signals.

5. The multi-format audio/video production system of claim 1, wherein the means to receive an input signal representative of a video program includes a digital video camera including:

a plurality of one or more image sensors;

an analog-to-digital converter circuit connected to the output of each image sensor to generate a digital signal representative of the sensed image; and

a digital signal processor configured to receive the digital signal from each analog-to-digital converter circuit and generate a digital video output signal in a predetermined input format for processing by one or more of the interface units comprising the graphics processor.

6. The multi-format audio/video production system of claim 5, wherein the digital video camera uses two charge-coupled-device image sensors, one associated with luminance, the other associated with chrominance.

7. The multi-format audio/video production system of claim 1 wherein the means to receive a video program includes a removeable high-capacity magnetic storage medium.

8. The multi-format audio/video production system of claim 1 wherein, in the event that a change in aspect ratio results from any of the format conversions, the controller further is operative to cause the change in aspect ratio to be visibly evident on the display device.

9. The multi-format audio/video production system of claim 1 wherein the graphics processor is operative to convert a 24 frame-per-second format input signal into a 30 frame-per-second NTSC-compatible format output signal.

10. The multi-format audio/video production system of claim 1 wherein the graphics processor is operative to convert a 24 frame-per-second format input signal into a 25 frame-per-second PAL/SECAM-compatible format output signal.

11. The multi-format audio/video production system of claim 1 wherein the graphics processor is operative to convert a 24 frame-per-second format input signal into an HDTV-compatible format output signal.

12. The multi/format audio/video production system of claim 1, including means to receive an RGB video signal having a chrominance bandwidth and a luminance bandwidth, and wherein the HDTV interface further provides means for reducing the chrominance bandwidth of the RGB video signal without reducing its luminance bandwidth, the HDTV interface including:

three low-pass filters, one associated with each of the R, G, and B components of the RGB video signal to remove all frequency components above a specified frequency;

an RGB-to-Y matrix circuit connected to receive each of the R, G, and B components, the RGB-to-Y matrix circuit being operative to combine the signals in predetermined proportions and produce a single luminance signal, Y;

a high-pass filter connected to the output of the RGB-to-Y matrix circuit to filter the Y signal to remove all frequency components below a specified frequency;

a Y-to-RGB matrix circuit connected to the output of the high-pass filter, the Y-to-RGB matrix circuit being operative to separate the high-pass-filtered Y signal into R', G' and B' components in the same proportion as previously combined by the RGB-to-Y matrix circuit;

three mixers, each adapted to receive an R/R', G/G' and B/B' pair, respectively, each mixer being operative to mix the signals of its respective input pairs and generate R", G" and B" signals having full luminance bandwidth and reduced chrominance bandwidth.

13. The multi-format audio/video production system of claim 1, the graphics processor further including means for transferring a program into the intermediate production format to a remote location equipped with one or more of the interface units.

14. A multi-format audio/video production system forming part of a general-purpose computer platform having a user input and color display, the system comprising:

means to receive an input video program in one of a plurality of input formats;

high-capacity video storage means;

means to convert the input program into a 24 frames-per-second (fps) production format, if not already in such a format for storage within the high-capacity video storage means and for review on the color display; and

means to convert the production format into one or more of the following output formats, either directly from the input or from storage:
NTSC at 30 fps,
PAL/SECAM at 25 fps,
HDTV at 25 fps,
HDTV at 30 fps, and
film-compatible video at 24 fps.

15. The multi-format audio/video production system of claim 14 wherein the means to convert the production format into one or more of the output formats includes interpolation means to expand the number of pixels associated with the production format.

16. The multi-format audio/video production system of claim 14 wherein the means to convert the production version into one or more of the output formats includes image sequencing means to convert the 24 fps production format into a 30 fps output format.

17. The multi-format audio/video production system of claim 14 wherein the means to convert the production format into one or more of the output formats includes means to increase the frame rate from the 24 fps production format frame rate to a 25 fps output frame rate.

18. The multi-format audio/video production system of claim 14, including output formats having the following image dimensions in pixels:

1024×576,
1024×786,
1080×720, and
1080×960.

19. The multi-format audio/video production system of claim 14 wherein the means to convert the production format into one or more of the output formats includes means to increase the frame rate from the 24 frames per second production frame to an output having a frame rate of substantially 30 frames per second.

20. In an enhanced personal computer having a color monitor, the method of producing a video program, comprising the steps of:

receiving an input video program;

converting the input video program into a production format having a predetermined frame rate and image dimension in pixels;

providing high capacity video storage means storing the program in the production format in the high capacity storage means;

displaying the video program on the color monitor using the predetermined frame rate and image dimensions in

pixels, including cropped versions of the program, with the extent of the cropping being visually evident on the monitor;

accessing the program in the production format from the high capacity storage means and manipulating the program to create a desired edited version of the program in an output format, including an output format having a frame rate and image dimensions in pixels different from that of the production format; and

outputting the desired edited version of the program in the output format.

21. The method of claim **20**, wherein the step of manipulating the video program to create a desired edited version of the program in a final format includes using an image-sequencing technique to convert from the production format at 24 frames per second to produce an edited version of the program in a final format at 30 frames per second.

22. The method of claim **20**, wherein the step of manipulating the video program to create a desired edited version of the program in a final format includes the step of interpolating to produce an edited version of the program in a final format having pixel dimensions greater than that of the production format.

23. The method of claim **20**, wherein the step of manipulating the video program to create a desired edited version of the program in a final format includes the step of increasing frame rate to produce an edited version of the program in a final format having a 25 frame-per-second rate.

24. The method of claim **20** wherein the step of manipulating the video program to create a desired edited version of the program in an output format includes creating a program having one of the following image dimensions in pixels:

1024×576,

1024×768,

1080×720, and

1080×960.

25. The method of claim **20**, wherein the step of converting the input video program into a production format includes converting the input video program into a production format characterized in having 24 frames per second.

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